# INVESTIGATION OF DISCHARGE OF FRESH WATER IN THE CANAKKALE STRAIT (DARDANELLES -TURKEY)

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**Abstract**

The Canakkale Strait (Dardanelles) is a water passage connecting the Aegean Sea and the Marmara Sea. Its NE/SW trend is interrupted by a north-south bend between Eceabat and Canakkale. The width of the Strait varies from 1.35 to 7.73 km, the narrowest part located between Canakkale and Kilitbahir. The average depth of the Strait is approximately 60 m; the deepest part reaches more than 100 m. The aim of this study is to determine the locations of fresh water discharge into the Canakkale Strait. For this purpose, 52 sample points were selected in the study area. The temperature, pH and salinity were measured at different depths of water in the Canakkale Strait (1, 5, 10, 20 and 30 m). A Geographic Information System (GIS) was used to create a tabular and spatial database, with the aim of integrating the physical properties in the Canakkale Strait. The results of this study show that discharge of fresh water is seen in four locations on the southeastern coast between Dardanos and Canakkale, and that the Aegean Sea and Marmara Sea water are mixing between Canakkale and Kilitbahir. In the future, these sources of fresh water may be needed as population increases in the region. However, water pollution in the Canakkale Strait may limit the use of this fresh water.

## 1. Introduction

Seawater intrusion into coastal aquifers has been investigated by several researchers since the study of Ghyben and Herzberg in the 1890s (Bear and Dagan



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1964; Frind 1982; Reilly and Goodman 1985; Gunay and Elhatip 1988; Voss and Anderson 1993; Back 1996; Elhatip 2003). Most recently, there have been several studies focusing on complicated aquifer conditions and the intrusion of saltwater (Croucher and O'Sullivan 1995; Huyakorn and others 1996; Sadeg and Karahanoglu 2001; Zhou and others 2003; Karahanoglu and Doyuran 2003). However, few studies have been done on the discharge of fresh water to the sea. Usually, water discharges from karstic rock to the sea have been studied. The discharge of the karstic water is high in the Aegean and Mediterranean seas (Gunay and Elhatip 1988; Elhatip 2003) Compared to other Neogene sedimentary sequences, the discharge of karstic water is easy to determine in sea water. Neogen sedimentary sequences are in an outcrop in the vicinity of the study area. For this study, the discharge of fresh water (coming from Neogen sequences), from urban areas of the Canakkale Strait is being investigated. A Geographical Information System (GIS) was used to ease monitoring of spatial and temporal changes (ESRI 1996; Kosmas and others 1997; Barazzuoli and others 1999; Thwaites and Slater 2000; Hudak and Sanmanee 2003). The distribution of physical properties of water is also monitored by GIS.

The Canakkale Strait (Dardanelles) is a very important water passage connecting the Aegean Sea and the Marmara Sea (Figure 1).

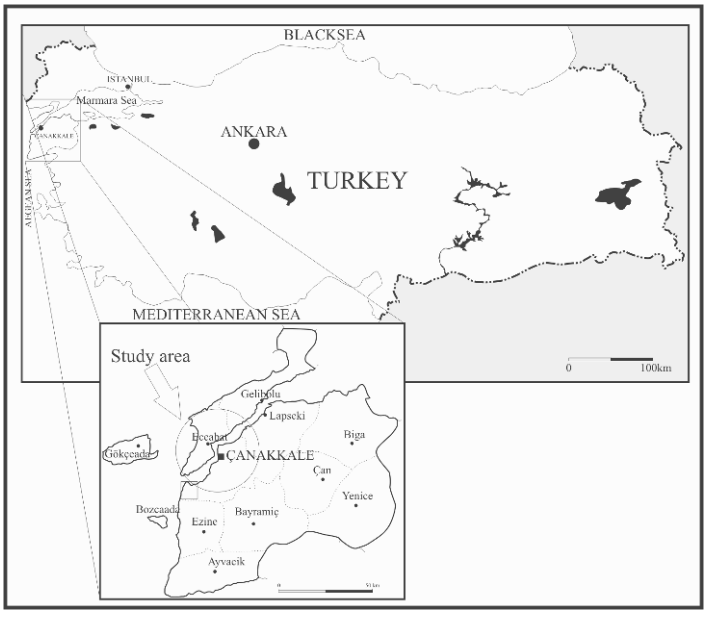



Figure 1: Location map of study area.

The Strait of Canakkale (Dardanelles) has two current systems. One of the currents is derived from the Aegean Sea, where the water density is high. The other comes from the Marmara Sea, characteristically of low density. Aegean water is typically flowing from the southwest to northeast under the Marmara Sea water.

The main goal of this study is to determine the locations of fresh water discharge into the Canakkale Strait.

## 2. Methods

Canakkale Onsekiz Mart University **"**R/V Bilim I**"** was used for this purpose. 52 points were selected within the study area for water samples (Figure 2). The temperature (T), pH, salinity, conductivity were measured at 1, 5, 10, 20 and 30 m depths. The physicochemical parameters were measured using a "6600 Model Multiple YSI Probe" connected to a computer, in situ**.** The Arc View 3.2 GIS (ESRI 1996) was employed to develop the maps. For the mapping procedure, the point themes were generated. The surface maps were then produced from the developed point themes by using Nearest Neighbor, an inverse distance interpolation technique, with 12 neighbors. The cell size for interpolation was 100 m. The study area border (Canakkale Strait border) was digitized from a topographical map scaled to 1/25,000 by using ArcInfo. Then data was exported to ArcView for mapping.

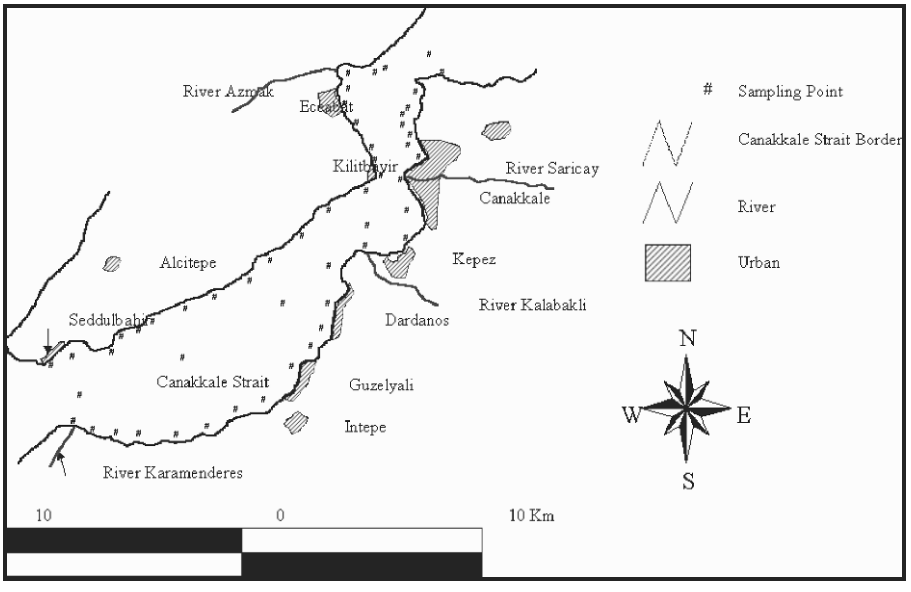



Figure 2: Study area and sampling points.

## 3. Results and Discussion

Two current directions are observed in the Canakkale Strait. The southwest flowing current from the Marmara Sea is of lower density than the northeast flowing current from the Aegean Sea.

### 3.1. TEMPERATURE AND SALINITY

Usually, temperature decreases with water depth, while salinity increases with water depth. However, in the Canakkale Strait, measurements show a different pattern. The temperature range is 6-20°C, and generally increases both with depth and with closer proximity to the mouth of the Marmara Sea (see Figure 3).

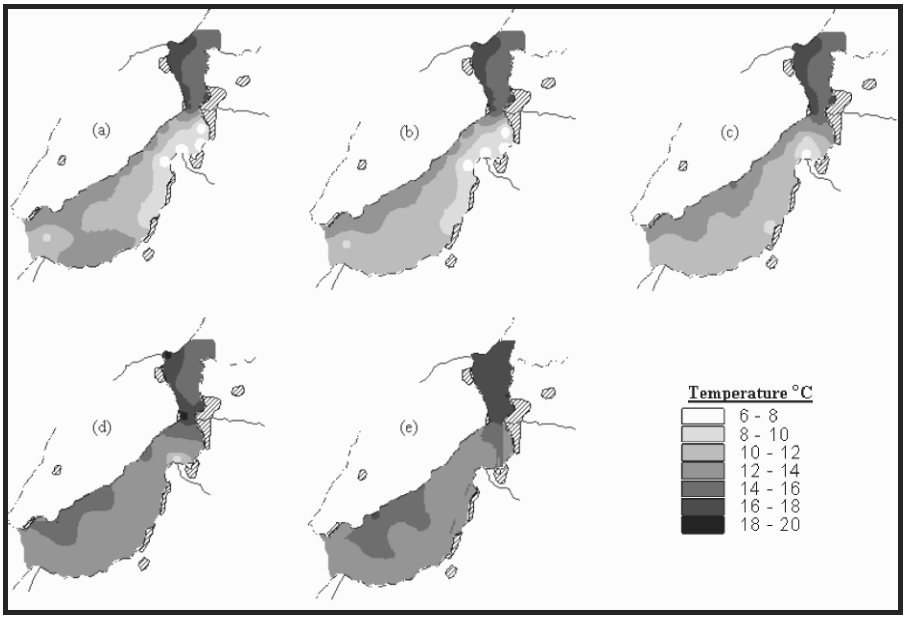



Figure 3: Distribution of temperature at different depths within the Canakkale Strait (a: 1m; b: 5m; c: 10m; d: 20m; e: 30m).

The salinity ranges between 20-40‰, and increases with water depth (see Figure 4).

The temperature increase with depth indicates turbidity in the Strait, and the mixing of the Marmara Sea and Aegean Sea waters. Temperature and pH measurements are highly variable at the narrowest part of the Canakkale Strait at Kilitbahir due to turbulence. The narrowing of the Strait also leads to different values to the northeast and southwest of Kilitbahir. The temperature and pH measurements to the northeast of Kilitbahir are higher than to the southwest (see Figures 3 and 5).

Temperature results show that discharge of the fresh water into the Canakkale Strait can be seen in the four sample locations between Dardanos and Canakkale at depths of 1 and 5 m; and at one location at 10 and 20 m depths. This point is affected by fluid discharge from the River Kalabakli (see Figure 3).

It is thought that the use of temperature techniques to measure fresh water discharges may give more accurate results depending on many internal and external factors, including the density equilibrium between fresh and sea waters, and other physical and structural properties of the coastal water-bearing formations.

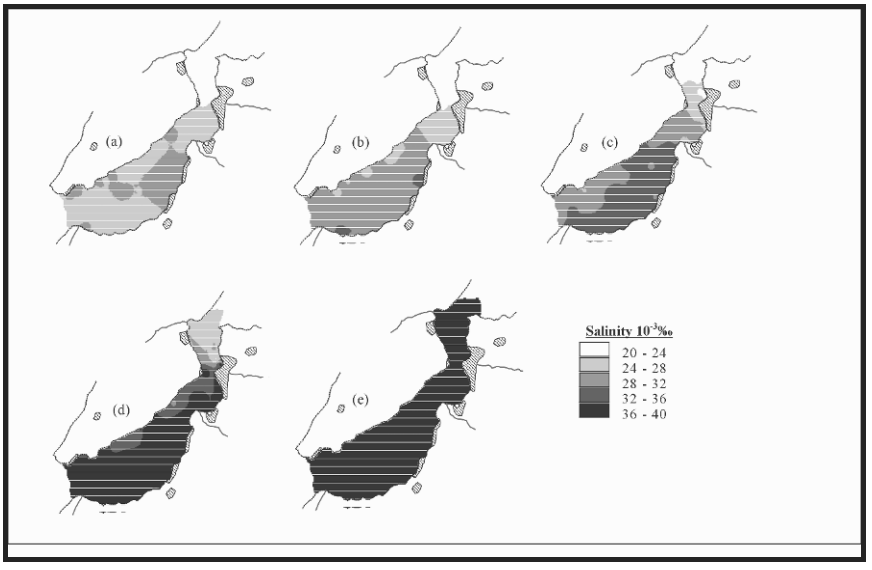



Figure 4: Distribution of salinity at different depths within the Canakkale Strait (a: 1m; b: 5 m; c: 10 m; d: 20 m; e: 30 m).

## 3.2. pH

The mean pH of Canakkale Strait is slightly basic at around 8.4. The average pH of Canakkale Strait is around 9 from 5 m to 20 m in the northeast of the Strait. During photosynthesis, hydrogen atoms are used by phytoplankton. The freshwater influx

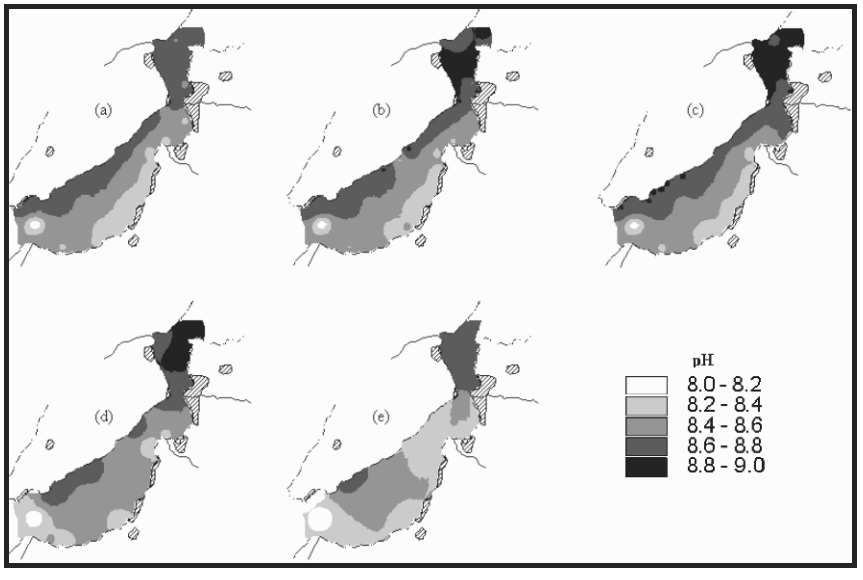



Figure 5: Distribution of pH at different depths within the Canakkale Strait (a: 1m; b: 5m; c: 10m; d: 20m; e: 30m).

is causing higher productivity levels, causing the water to become more basic in that area. Respiration and the breakdown of organic matter will lower the pH in the southwest of the Strait (Figure 5).

## 4. Conclusion

Population growth, urban expansion and economic development have persistently raised the demand of water supply, and consequently, greatly increased the exploitation of fresh water around the Canakkale Strait in the last several decades. This area is one of the important tourist sites in Turkey. In addition, the Canakkale Strait (Dardanelles) is a very important water passage connecting the Aegean Sea and the Marmara Sea. Therefore, this area will see expansion in the near future.

This study shows four points of fresh water discharge into the Canakkale Strait. This freshwater is coming from groundwater aquifers in the region. Much of the fresh water in the vicinity of the study area is discharged into the Canakkale Strait, Aegean and Marmara Sea. At present, the groundwater supplies appear to be sufficient enough for domestic and irrigation demands. But the population along the southeast coast of the Canakkale Strait is rising and the demand for freshwater increasing. This study has pinpointed the locations of freshwater discharge, so that if freshwater is needed in the future, it may be possible to extract it from these locations, prior to discharge into the strait or from the strait itself.

## 5. Acknowledgements

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